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PROCESS AND DEVICE FOR OPERATING A
WEAR-AFFLICTED DISPLAY

The invention concerns a wear-afflicted display and a process for operating a wear-afflicted display, in particular a plasma display panel, FED, or an organic display, with defined pixels, in which each pixel is allocated a memory address in a memory element for recording the operating time of each pixel and is furthermore integrated over the operating time and the operating intensity in order to determine a pixel wear value, and a pixel wear value and/or a characteristic that is proportional to the respective pixel wear values is stored for each pixel, and in addition a corrective signal for the equalization of the pixel wear is generated based on the evaluation of the respective pixel wear values by means of at least one logic element.

A display such as this is known from United States patent application 2003/0063053 A1, in which the wear and display times are recorded for each individual pixel. From the recorded values are calculated correction values, with the aid of which the brightness of each individual pixel can be adapted in such a way that a low wear occurs. These values are saved regularly in the memory elements respectively allocated to the image elements, so that the actual status of the display can be used to calculate the correction values. A comparison of adjacent pixels can thus be made, based on which an equalization of the brightness and the wear of the display is possible. The brightness is controlled in such a way via the power supply of the

individual pixels that it can only fluctuate within predetermined limits, and in particular does not exceed a predetermined limit. A correction of already existing irregular wear can be achieved by way of an intentional higher wear of the otherwise less worn pixels.

Likewise already known is a display described in German patent publication DE 100 10 964 A1, in which it is differentiated between the operations for each of the colors red, green, and blue for each pixel. This display is characterized especially in that the individual monochrome pixels are not of equal size, but are adapted in size to the wear of the corresponding colored phosphorous display. Furthermore, it is provided therein to monitor and equalize the actual wear of the individual pixels similarly as in the previously described process with the object of a white compensation.

A process for protecting against the pixels burning-in into the plasma display is also known from the abstract of the Japanese patent application JP 2002091373.

In this previously known process, the display time of each pixel of a display is recorded. A video signal is then generated in dependence upon predetermined difference values or threshold values and is made to be displayed on the display in order to configure approximately uniformly the display time of each phosphorous element of the display.

The previously mentioned plasma display panels, called for short PDPs, consist essentially of two glass panes, which are assembled together with a precise fit. Between the two glass substrates are arranged cells, which are filled with a noble gas, preferably neon or xenon. In the lower substrate, these cells are coated with phosphorous in the basic colors red, green, and blue. Thin electrodes are applied on the lower and upper transparent glass substrates. A voltage, which generates the ultraviolet radiation that is applied for controlling a discharge process on the mentioned electrodes, is generated with a plasma pulse generator. This ultraviolet radiation causes the phosphorous coating of the display to glow. Each color can then be generated by means of a combination of the basic colors red, green, and blue. Depending on the content of the image is thus addressed each one of the individually separated color cells.

The particular advantages of the plasma technology rest in the high image brightness that can be obtained, which is exclusively limited by the consumption of the phosphorous and allows an observation angle of at least 160 degrees. Furthermore, the eventual plasma displays have excellent contrast values, while a good black value of the image representation and/or an eventually desired color correction, possibly by preventing an orange sting, can be achieved by means of a corresponding tinge of the frontal substrate or by using a suitable filter element arranged upstream.

However, these plasma displays have disadvantages that are immanent to the system. Similarly as for the tube monitor, the phosphorous represents a consumption agent that limits the life expectancy of the display. If upright images are represented for a long time on the display, the phosphorous and the displayed picture burn themselves into the display.

The luminance of the phosphorous and also the brightness and the contrast of the plasma display disappear inevitably with each operating hour.

The manufacturers of plasma display panels currently recommend the use of screensavers in order to mitigate or prevent the described burn-in effect. However, it is a concern that the effect can occur also with running or moving images, such as perhaps feature films, possibly if the logo of a television station or the known black bars are permanently displayed at the edge of the picture, and the problem of a partially increased or reduced wear occurs thus in this display section.

Furthermore, it must be taken into consideration with regard to the wear characteristic of phosphorous that the wear characteristic of the basic colors red, green, and blue of phosphorous differ from each other, so that the color temperature range of a display can indeed change over its service life. The use of screensavers provides no useful effect with regard to this problematic.

As an alternative are known further processes, such as possibly image shifting – a method of intentional image

scrolling for equalizing the wear – or an automatic brightness reduction in stills.

From JP 2002006796 A is known a further process for improving the long-term behavior of the plasma display. The individual operating times of the red, green, or blue phosphorous elements for the entire display can be analyzed according to this process by recording a time integral for each pixel. Correction signals for each of the three basic colors red, green, and blue can be generated based on these determined wear values in order to keep the brightness and the color temperature of the display constant, if possible over long periods of time. The indication of the red, green, and blue graphic data forwarded within an image file is then corrected during the further activation of the display by means of the mentioned correction signals. A separate wear analysis for each pixel and a corresponding separate correction of each pixel correction of the wear is not provided. The different pixel loading can thus not be ignored within the scope of the previously known process.

From DE 43 34 640 A1, it is known in connection with the previously explained problematic to automatically display so-called inverse images instead of the already mentioned screensavers through a corresponding inverse switching when defined threshold values are reached. The display or the inverse switching of the respectively displayed image is carried out in dependence upon temporal specifications or otherwise predeterminable parameters. An analysis or recordation of the pixel wear is not provided herein.

Based on this state of the art, it is an object of the invention to create a wear-afflicted display or a process for operating such a display, with which a constant image quality can be achieved over a long time period or the service life of the display can be extended.

This object is attained with a process according to claim 1 or with a display according to claim 31. Advantageous embodiments of the invention result according to the dependent claims 2 to 30 as well as 32 to 34.

As already mentioned, in wear-afflicted displays, especially plasma displays, there exists the problem that specific partial areas are more frequently or intensively utilized and the monitor can consequently be damaged by means of a so-called burn-in. Furthermore, it should be noted that the wear of the phosphorous with reference to the basic colors red, green, and blue is differently represented, so that the wear of the basic colors is different. The previously described effects can be eliminated or mitigated based on the use of the process of the invention and a possibility can even be created for equalizing the partial wear. For this purpose, the activation of the individual pixels is adapted within the scope of the invention to the wear in the current status of the display. In the first hours of operation, in which the burn-in effect is greatest, the pixels are therefore loaded with a particularly low brightness value in comparison with conventional displays. With increasing wear, the brightness is then continuously increased according to a stored characteristic curve or characteristic field. In

order to prevent the different wear of the basic colors, the operating time and operating intensity according to the basic colors red, green, and blue is separately recorded and a pixel wear value or a characteristic that is proportional to this pixel wear value is stored for each pixel by means of a memory element that is clearly allocated to each pixel.

A correction of the graphic data to be displayed can be carried out for each separate pixel by means of these data with the object of reducing, equalizing, or preventing the wear on the plasma display. It should be noted herein that in a typical plasma color display is used an image repetition frequency of usually up to 60 Hz, while resolutions of 1280 x 780 pixels or higher are used, so that a constant data flow of after all 177 MB per second accumulates with a color depth of 8 bit per color. This data flow must then be processed and stored, for example, by integration. The value to be stored is clearly over 8 bit per color. Already the simple adding of one 8 bit color value over a period of 4 minutes requires a memory of 22 bit per color point. A data flow of 1.5 GB per second is probably required if the memory value must not only be read but also written.

The invention solves the problem of the considerable data flow that is to be processed by means of an intelligent data management.

For this purpose, according to claim 1, the permanent integration of the pixel wear for each individual pixel is

completely decoupled from the determination of the pixel correction values resulting from it, so that a rapid cycle is available to determine the current pixel wear and a temporally decoupled, clearly slower cycle with correspondingly reduced processor performance can be used to determine the correction value of individual pixels. For this purpose is used a two-stage memory element, which comprises a volatile and a non-volatile memory. The use of the volatile memory is offered from the technical point of view based on the speed of this memory element, since the decoupling of the cycles that is attained in this way, and in particular the forgoing of a permanent or synchronous calculation of the correction values, represents an effective contribution to the reduction of the processor load and of the volume of data to be processed. Furthermore, volatile memory elements are more advantageous than non-volatile memory elements. In addition, typical non-volatile memories have generally a maximum allowable number of deletion cycles, which can be clearly below the service life of the PDPs in fast memory cycles.

Within the scope of the invention, the volatile memory element is not only used for the enlargement of the available memory space, but rather almost as an overflow for processing the described, considerably accruing volume of data. In this way, within the scope of the invention, the accruing pixel wear values are initially written into the volatile memory in a first memory step, and are transferred into the non-volatile memory only in a second memory step. In the correct understanding of the memory space management, it should be assumed that the previously

explained cycles of the storage are decoupled from each other and run asynchronously.

In this way, it has been shown to be advantageous to not secure the data in case of a shutdown of the display, so that the components of the invention do not require a measure that requires a power supply such as, for example, a buffer accumulator. The inaccuracy resulting from this can be disregarded. A continuous transfer of data is otherwise carried out from the volatile memory into the non-volatile memory in the operation of the display.

When the display is turned on, the data that are retained in the non-volatile memory are then rewritten into the volatile memory in a first step in order to later write these data in the access of the memories that are required for the wear-reducing operation of the display.

In an advantageous embodiment, the memory is immediately started, at first without the corresponding correction of the image graphic data, regardless of the fact that the rewriting process of the data into the volatile memory is not immediately completed.

In the practice, it has been shown to be advantageous if one or several SDRAM components are used as volatile memory element and one or several flash components are used as non-volatile memory element.

Aside from the use of a volatile or non-volatile memory element, it has been shown to be advantageous if the volume

of data to be processed is reduced by means of a correspondingly skilled data processing. This can occur, for example, by reducing the accuracy of the respectively recorded pixel wear values, for example, by not storing the bit with the respectively lowest value, the so-called "least significant bit" – "lsb" – or instead of an absolute amount, which represents the current pixel wear value, storing a difference value between the respective pixel wear value and a predetermined (for example, maximum, minimum, or medium) pixel wear value. In this way results a reduction of the stored volume of data insofar as the difference value becomes lower as usual than the absolute value that is otherwise to be stored.

In order to address the different wear characteristics of the phosphorous elements in the basic colors red, green, and blue, it has proven advantageous if the intensity of the activation of the individual pixels is recorded individually for each pixel or separately by sections for each of the basic colors red, green, and blue.

In a further process step takes then place, depending on the recordation of the aforementioned data, a correction of the graphic data to be displayed in dependence upon the reaching of predetermined threshold values, while the increase and/or reduction of the intensity of the display of the individual pixels can be carried out automatically, interactively, and/or manually.

In a likewise advantageous embodiment can be generated a correction image, whose indication leads to the fact that

the different individual pixel wear values are raised to a general wear level as repair measure for a wear-afflicted display. The plasma display is again equalized after the corresponding indication of the correction image and the original color temperature of the display is preferably restored.

Also the display of the correction image can be carried out automatically, interactively, and/or manually in dependence upon predetermined threshold values.

In order to accelerate the previously described repair of the plasma display or the equalization of the pixel wear values, it may be practical to activate at least selected individual pixels above the otherwise maximum allowable or at least operate with increased image brightness.

In order to be able to carry out the previously described corrections, it is practical if at least one logic element, which multiplies the red, green, and blue image graphic by means of the correction data generated by the logic element(s), is allocated to the memory element that is necessary for the recordation of the pixel wear values, and the display is activated in the following with the correspondingly corrected graphic data.

The correction data are determined based on the evaluation of the pixel wear values stored in the memory element allocated to the display and/or form characteristic fields.

The generation of the correction values must therefore not occur permanently, but can occur at intervals or by cycles. It is sufficient if the correction values are generated possibly multiple times per hour and the work is carried out afterward with these corrective values until the next determination of the correction values. These measures represent an effective method for reaching the required processing speed. The cycles for feeding the pixel wear values and their integral summation occur also decoupled from the determination of the correction data.

The determination of the correction data can of course be carried out in dependence upon further predetermined parameters, such as possibly the individual phosphorous characteristic of the separately used display, the allowed brightness of the display, or also the total brightness of the display separated according to the basic individual colors red, green, and blue. The current operating temperature of the individual display, the age of the display, as well as the color temperature, and also the limited maximum brightness are further parameters, which can be taken into consideration in connection with the determination of the correction data from the mentioned logic.

The process of the invention can also be advantageously used to retrofit already existing displays, in particular plasma displays, by retroactively allocating a memory element pursuant to the invention and at least one corresponding logic element to these displays, wherein an evaluation of the individual wear status of the retrofitted

display is carried out in a first process step and a first correction step is then conducted. In addition to this, a transfer into a wear-protected constant operation can take place according to what was previously described.

It has also been shown to be advantageous in display technologies that have highly differentiated wear characteristics, such as, for example, in OLED displays, to proportionately increasingly display the corresponding colors or the corresponding color and to activate these less in the beginning with the aid of the corrected pixel values (R', G', B') by means of this process, and only to correct them over time. In this way, these display technologies achieve a longer and/or a required service life and/or a higher total brightness.

It has also been shown to be advantageous if the display is possibly scalable with regard to the picture resolution and can thus be adapted to the individually changing conditions based on the different operating time.

It has also been shown to be advantageous in the process to integrate into the logic element(s) (2) the logic of a graphic controller without the otherwise customary graphic memory and thus to be able to jointly utilize the volatile memory.

As additional or alternative correction possibility can be utilized the plasma pulse generator that is allocated to the display by forwarding the correction data that are predetermined by the logic directly to the plasma pulse

generator and producing thus a special brightness control of the pixels of the display in the plasma pulse generator, which is individual to each pixel, in dependence upon these correction data, and incidentally applying the otherwise unchanged graphic data on the RGB input of the display.

The process according to the invention can be advantageously operated in this way with the known processes for wear-protected operation of such displays, in which it has also been shown to be advantageous if the process according to the invention is connected downstream or as a subordinate control circuit.

The process of the invention is advantageously used in connection with a wear-afflicted display pursuant to the features of claim 31. This wear-afflicted display is characterized in that a memory element for recording the individual pixel wear values is allocated to each pixel and corrected RGB graphic data are generated from the pixel wear values by means of at least one logic element and are applied at the input of the display.

As an alternative, or in addition, the plasma pulse generator of the wear-afflicted display can be used for the previously described individual pixel brightness control of the display.

The invention will be described in the following with reference to several exemplary embodiments, wherein:

Fig. 1: shows a block circuit diagram of a plasma display panel (PDP) with memory and logic element,

Fig. 2: shows a functional diagram for data transfer between logic element and memory element,

Fig. 3: shows a diagram of the process for determining the corrected graphic data in the logic element,

Fig. 4: shows a further diagram of the process for determining the corrected graphic data in the logic element, and

Fig. 5: shows an alternative modulation of the plasma pulse generator of a display in a block circuit diagram.

Fig. 1 shows a block circuit diagram of a wear-afflicted display 1, which in the exemplary embodiment should be a so-called plasma display panel, PDP for short. The display 1 is in data connection with at least one logic element 2, that is, possibly and ASIC, FPGA, or an otherwise integrated IC circuit, and a memory element 3. To the logic element(s) 2 is allocated in addition a parameter memory 4, which can consist of a connected external memory. As an alternative, the parameter memory 4 can be realized also as partial element of the non-volatile memory 6. In

the parameter memory 4 can perhaps be stored the individual phosphorous characteristic of the PDP display 1.

The memory element 3 allocated to the display 1 consists of a volatile memory 5 and a non-volatile memory 6. The volatile memory 5 is comprised by one or multiple SDRAM components and the non-volatile memory 6 is comprised by one or multiple flash memories.

In the memory element 3, each pixel of the display 1 is assigned a fixed memory space or a defined memory address. Individual pixel wear values R*, G*, B* are separately written into the memory element 3 for each pixel according to the basic colors red, green, and blue. The pixel wear values R*, G*, B* that are individual to each pixel are thus written into the volatile memory 5 in a first storage step and are continuously rewritten in the non-volatile memory 6 during operation. The buffering of the non-volatile memory 6 with a volatile memory 5 is offered from the technical and economical point of view because of the considerable volume of data that are produced.

The display 1 serves for displaying graphic data, that is, for example, in a plasma TV, the display of the pixel data R, G, B supplied by the television station. The pixel data R, G, B can also be forwarded separately according to the basic colors red, green, and blue, so that it can also be differentiated between the three colors with regard to the pixel data R, G, B. In contrast to the conventional displays, the display 1 pursuant to the invention is not operated with the pixel data forwarded by the television

station, but rather with corrected pixel data R', G', B'. The corrected pixel data R', G', B' are calculated by the digital logic element 2, taking into consideration the parameters located in the parameter memory 4, such as possibly the individual phosphorous characteristic of the display 1, and the pixel wear values R*, G*, B* located in the memory element 3.

The storage of the individual pixel wear values R*, G*, B* and the interaction of memory element 3 and logic element 2 are shown in more detail in Figure 2.

As already mentioned, the memory element 3 comprises a volatile memory 5 and a non-volatile memory 6. Therein, the individual pixel wear values R*, G*, B*, which are proportional to the operating time and intensity of the operation of the respective pixel, are written first as volatile pixel wear values R^f, G^f, and B^f in the volatile memory 5. The most significant bits of the pixel wear values R^a, G^a, B^a are written into the non-volatile memory 6 in terms of an overflow.

The pixel wear values that are written into the memory elements 5 and 6 are constantly integrated over the operating time of the respective pixel by means of a corresponding addition loop, and from these are generated integral values, such as perhaps R^{int}, then real pixel wear values R^v, G^v, and B^v,, which are then stored depending on the value in the volatile memory 5 as R^{vf}, G^{vf}, and B^{vf}, or in the non-volatile memory 6 as R^{vn}, G^{vn}, and B^{vn}, and the previous value R^{int}, G^{int}, and B^{int} is reset. From the stored

values is determined an individual pixel correction signal R^{kor}, G^{kor}, or B^{kor} by means of the logic element. By means of these correction signals are then determined, as already mentioned in connection with Fig. 1, the corrected pixel data R′, B′, and G′.

Furthermore, the logic element 2 ensures that the data stored in the non-volatile memory 6 are first rewritten into the volatile memory 5 when the display 1 is turned on. Until then, it is possible of course to operate with an initially uncorrected display indication.

The logic element 2 determines thus correction values R^{kor}, G^{kor}, or B^{kor} that are individual to each pixel, while taking into consideration the parameter values stored in the parameter memory 4, while the determination of these correction values does not occur continuously but by cycles, that is, possibly at defined intervals or when predetermined threshold values are exceeded.

A careful differentiation must therefore be established between the cycles for determining the corrected pixel data R′, B′, and G′, and the integration cycle for determining the pixel wear values R^{int}, G^{int}, or B^{int}.

According to Figure 3, the pixel data R, G, B are processed by means of these correction data R^{kor}, G^{kor}, or B^{kor}, and the display 1 is finally loaded with the corrected pixel data R′, G′, B′.

An example of the determination of the corrected pixel data is shown in detail in the flow diagram shown in Figure 3.

Figure 3 shows the processing of a pixel value with the fast cycle for the red channel of a cell. In order to possibly take into consideration the system-induced maximum brightness, the process pursuant to the invention can obtain the information from the control mechanism of the display. Within the scope of the process pursuant to the invention, this mechanism can also be automatically reproduced in that this is taken into consideration with an external multiplier 10b for wear determination. The control itself is carried out with an internal multiplier 10a.

Initially, the actual pixel value R is supplied together with the correction value R^{kor} to a main multiplier 12. By means of this multiplication of the value R by the individual pixel correction value R^{kor} is additionally generated a corrected pixel value R', which can be optionally corrected by means of the internal multiplier 10a that can be connected to the display 1 as well as also to the optional external multiplier 10b to generate a corrected value with adjusted brightness. This corrected value, which has an adjusted brightness, is integrated into a loop by means of an integrator 11, and is combined to form an integrated pixel wear value R^{int}. From this integrated pixel wear value R^{int} is then determined a correction value R^{kor} by means of the logic element 2, which depending on the individual pixel wear can have a value that is higher or lower than 1. Under this, it should be

understood that an increase or a reduction of the pixel wear can be predetermined for the correction value.

The determination of the corrected pixel value R′ that is to be ultimately connected to the display is shown again in detail as a process diagram in Figure 4. According to the representation of Figure 4, as already mentioned, the actual pixel value R is first fed together with the correction value R^{kor} to the main multiplier 12. By means of this multiplication of the value R by the individual pixel correction value R^{kor} is finally generated a corrected pixel value R′, which is optionally still acted on by the internal multiplier 10a that is connected to the display 1 as well as also optionally to an external multiplier 10b to generate a corrected value with adjusted brightness. This corrected value with adjusted brightness is then integrated into a loop by means of the integrator 11 and is combined to an integrated volatile stored pixel wear value R^{vf}. This value is then integrated further with the already previously volatile stored pixel wear values R^{vf} and stored in the volatile memory element as volatile pixel wear value R^{vf}.

According to a further parallel loop, it is continuously checked with a slow cycle if a new calculation of the correction data R^{kor} is required, or if the work can be continued with the previous correction data.

It is furthermore ensured with a slow cycle in a further parallel loop that the volatile stored pixel wear values R^{vf} are continuously written into the non-volatile memory as

non-volatile stored pixel wear values R^{vf}. The forwarding of volatile pixel wear values R^{vf} to the non-volatile pixel wear values R^{vn} does not have to be completed. It has also been shown to be advantageous to only forward the high-value bits, the so-called "most significant bits" – "msbs" – and to leave unchanged the less significant bits until the following slow cycle.

Apart from that, the pixel value R′ that is ultimately to be applied on the display can be generated from the correction values R^{kor} determined in the easiest way by multiplication with the optional value with brightness correction. As an alternative, this can also be carried out by means of one or several additions.

According to Figure 5, the digital logic element 2 can directly supply the plasma pulse generator 13 allocated to the plasma display 1 alternatively or in addition with the pixel correction values R^{kor}, G^{kor}, B^{kor} generated according to the previous embodiments. In this embodiment, the digital logic element 2 loops the pixel data R, G, B predetermined by the original graphic signal without any change directly through to a RGB input 14 of the display 1.

Finer gradations in the individual pixel brightness control of the plasma display 1 can be carried out in this way.

In the previous was consequently disclosed a process and a device for wear-protected operation of a wear-afflicted display 1, in particular a plasma display, which is characterized in that an individual pixel equalization of

the wear level of the display 1 is carried out taking into consideration the individual parameters of the plasma display, in which this process is assisted respectively by an intelligent memory and data management.

LIST OF REFERENCE CHARACTERS

1	Display
2	Logic element
3	Memory element
4	Parameter memory
5	Volatile memory
6	Non-volatile memory
10	Brightness control
10a	Internal multiplier
10b	External multiplier
11	Integrator
12	Main multiplier
13	Plasma pulse generator
14	RGB input
R, G, B	Pixel data
R^{kor}, G^{kor}, B^{kor}	Pixel correction values
R', G', B'	Corrected pixel values
R*, G*, B*	Stored pixel wear values
R^{vf}, G^{vf}, B^{vf}	Volatile stored pixel wear values
R^{vn}, G^{vn}, B^{vn}	Non-volatile stored pixel wear values
R^{int}, G^{int}, B^{int}	Integrated pixel wear values